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Susceptibilities of *Lygus lucorum* Meyer-Dür (Hemiptera: Miridae) from five cotton-growing regions in Shandong, China to selected insecticides

GUO Tian-E, ZHANG Zheng-Qun, ZHOU Chao, LIU Feng, MU Wei*

(Shandong Key Laboratory of Pesticide Toxicology and Application Technique, College of
Plant Protection, Shandong Agricultural University, Tai'an, Shandong 271018, China)

Abstract: Susceptibilities of the green plant bug, *Lygus lucorum* Meyer-Dür collected from five cotton-growing regions in Shandong Province, China, to endosulfan, malathion, chlorpyrifos, bifenthrin, methomyl, carbosulfan, imidacloprid and fipronil, were determined by glass-vial bioassay in 2009 in order to choose efficient insecticides for controlling green plant bugs in different regions. Dose-response results indicated that *L. lucorum* from five cotton-growing regions were susceptible to malathion, chlorpyrifos, carbosulfan, bifenthrin and imidacloprid at LC_{50} values. Toxicity data indicated that *L. lucorum* collected in Liaocheng (LC) was more susceptible to methomyl, endosulfan and fipronil than those in other four regions. The results indicated that the LC_{50} values of Binzhou (BZ) population for methomyl, endosulfan and fipronil were 5.12-, 6.04- and 39.80-fold higher than those of LC population, respectively, and the LC_{50} values of Qufu (QF) population for methomyl, endosulfan and fipronil were 22.12-, 5.48- and 22.80-fold higher than those of LC population, respectively. The populations collected in BZ and QF was less susceptible to methomyl, endosulfan and fipronil. The toxicity sequence of 8 insecticides to *L. lucorum* was ranked as follows: fipronil > methomyl, bifenthrin, endosulfan > malathion, chlorpyrifos > carbosulfan > imidacloprid. The susceptibilities of *L. lucorum* adults from Dezhou (DZ) to 8 insecticides were hardly changed during July and October in 2009. The current study may provide a better understanding of insecticide efficacies to *L. lucorum* and develop efficient pest management strategies in those cotton-growing regions.

Key words: *Lygus lucorum*; cotton; field population; resistance; insecticide susceptibility; insecticide; toxicity

1 INTRODUCTION

Recently, due to less usage of broad-spectrum insecticides on transgenic (Bt) cotton in northern China, the green plant bug, *Lygus lucorum* Meyer-Dür (Hemiptera: Miridae), has emerged as a major pest of cotton crops (Wu *et al.*, 2002; Lu *et al.*, 2008). The damage of *L. lucorum* to cotton from Dezhou (Xiajin), Qufu, Liangshan and Binzhou has gradually increased with the enlargement of Bt cotton areas, which resulted in sharp decrease in cotton production. At present, the prevention and control of the green plant bug are still at the initial stage in China, which mainly rely on chemical control (Liu *et al.*, 2007).

Andres *et al.* (1955) initially reported resistance in *Lygus hesperus* Knight to dichloro-diphenyl-trichloroethane (DDT) (Thomas *et al.*, 1977). Snodgrass *et al.* (2000) reported that *L. lineolaris* (Palisot de Beauvois) became resistant to organophosphate insecticides carbicron, permethrin and parathion-methyl. Zhu *et al.* (2004) found that field populations from Mississippi region became resistant to the pyrethroids pesticide permethrin, and at the same time also became resistant to three kinds of organophosphate pesticides, especially malathion. But so far few studies about *L. lucorum* were reported abroad. In China, Li *et al.* (2008) determined toxicities of fipronil, imidacloprid, chlorpyrifos and other pesticides to the 3rd instar nymphs of *L. lucorum* using glass-vials method, and found that the toxicities of fipronil and chlorpyrifos were highest. In addition, summary reports about integrated control of *L. lucorum* concluded that imidacloprid, beta-cypermethrin, fipronil, malathion, carbosulfan, fenvalerate and other agents were recommended to control green plant bugs in the field (Zhang, 2007;

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作者简介：郭天娥，女，1984 年生，山东泰安人，硕士研究生，从事农药毒理与应用技术研究，E-mail: guo25096@163.com.cn

* 通讯作者 Corresponding author, E-mail: muwei@sdau.edu.cn

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Li *et al.*,2008; Liu *et al.*, 2008).

Monitoring susceptibility level is an important basic work for integrated management against pests, and it plays an important role in the efficient pesticides selection to field control (Chen *et al.*, 2009). There is no direct comparison of the susceptibilities of *L. lucorum* from all five major cotton-growing regions in Shandong province. Our previous study reported that endosulfan, malathion, chlorpyrifos, bifenthrin, methomyl, and fipronil showed excellent activities against *L. lucorum* among 30 insecticides (Zhang *et al.*, 2009). Because endosulfan, malathion, chlorpyrifos, bifenthrin, methomyl, carbosulfan, imidacloprid and fipronil are currently applied to control pests in cotton-growing areas in China, we chose these 8 insecticides in this study. The objectives of this study were to generate baseline data for field-collected populations of *L. lucorum* and to determine their susceptibilities to these insecticides. At the mean time, we determined the variance of the susceptibilities to eight insecticides of *L. lucorum* in Dezhou (Xiajin) from July to October in 2009.

2 MATERIALS AND METHODS

2.1 Insects

Using gently swung sweep nets, the green plant bugs were collected from *Humulus scandens* (Lour.) near cotton fields in Liaocheng (Dongchangfu), Liangshan (Xijiao area), Qufu (Nanjiao area), Binzhou (Nanjiao area) (in August, 2009), and Dezhou (Xiajin) (from July to October, 2009) (in cotton field in July) of Shandong Province (Fig. 1). Bugs were aspirated from the sweep nets after collection in the field and placed into plastic insect boxes (23 cm long × 15 cm wide × 9 cm high) with the green bean pod *Phaseolus vulgaris* L. The beans were washed in detergent and soaked in a 0.5% sodium hypochlorite solution as described in Lu *et al.* (2008) to remove or oxidize any insecticide residue on them.

The laboratory colony of green plant bugs for determining the toxicity of insecticides was established in our laboratory conditions. The bugs were held in plastic insect boxes with 50 ~ 60 adults per box provided with green bean pods and honey solution under the laboratory conditions of 25 ± 1℃, RH 40% ~ 65%, 14L∶10D. During the mating period, the boxes containing adults were checked daily for oviposition. If eggs were found, the green bean pods on which eggs were oviposited needed to decrease the water content for avoiding the rot of beans and increasing egg hatching rate, and then were removed and transferred to new containers. After eggs hatched and nymphs dispersed from eggs (*i. e.*, 1 d after hatching), individuals of the generation were placed individually into separate plastic insect boxes with shredded paper that was placed snugly in position. The container lid had the inner portion cut out and a piece of gauze placed over the top to seal the container. Nymphs were fed with clean green bean pods placed inside the containers till the desired developmental stages for test. The 3 ~ 5-day-old adults of the second generation indoor of green plant bugs were used for toxicity bioassay test.

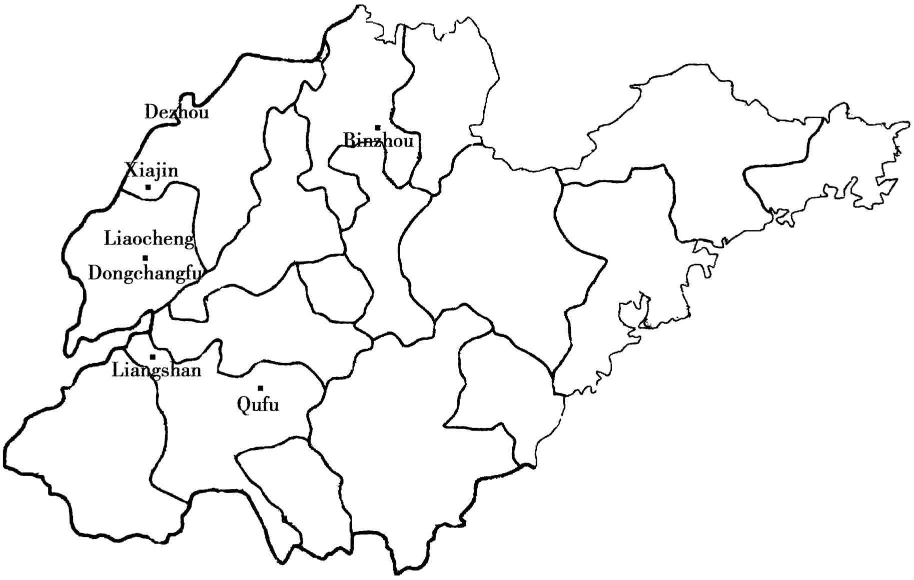

Fig. 1 Leading cotton-producing regions in Shandong Province, China, where green plant bugs, *Lygus lucorum* Meyer-Dür, were collected and tested in this study

2.2 Insecticides

Eight insecticides were used in this study: 95% endosulfan (Israel Makhteshim-Agan Industries Ltd.); 95% malathion (Sinochem Ningbo Chemical Co., Ltd.); 97% chlorpyrifos (AI, America Dow AgroSciences LLC.); 98% methomyl (Jiangsu Changlong Chemicals Co., Ltd.); 91% carbosulfan (Shandong Vicome Lunan Pesticide Co., Ltd.); 95% imidacloprid (Zhejiang Hisun Chemical Co., Ltd.); 97% bifenthrin (Jiangsu Yangnong Chemical Co., Ltd.); 95% fipronil (Hangzhou Bayer Crop Science Co., Ltd.).

2.3 Bioassays

Glass-vial bioassay (Snodgrass, 1996) was used to determine the toxicities of insecticides to adult green plant bugs. Adults were randomly selected and placed into 20 mL glass scintillation vials (28 mm in diameter and 61 mm high). Each insecticide was applied by pipetting 0.5 mL of insecticide dissolved in acetone ($\geqslant$ 99.7%, analytical reagent) into each vial. Serial dilutions were used to obtain desired concentrations. Each vial was slowly rolled for several minutes until an even layer of insecticide dried on its inner surface. Vials in control treatments received only 0.5 mL of acetone. Vials were used on the same day they were coated with insecticides. Then 2 adults were transferred from the plastic insect box into each glass scintillation vial. A small piece of washing and sterilized green bean pod (cut transversely) about 3 mm thick was added to each vial as food for the adults, and one-layer gauze was used to seal each vial. Vials were held during the test in an upright position under laboratory conditions of 25 ± 1℃, 40% -65% RH, and 14 L:10 D.

All bioassays had 3 replications for 6 different insecticide concentrations, and each replication for each concentration included 5 vials each with 2 adults. Mortality was determined after 24 h, and adults were considered dead if they were unable to stand normally or walk, or there was no movement when they were prodded with a fine-haired brush.

2.4 Data statistics and analysis

Data were corrected based on the control mortality using Abbott's formula (Abbott, 1925) before analysis, and the data were analyzed with SAS/STAT® version 6.12 (SAS Institute Inc., 1997). Statistical differences between LC_{50} values were determined using the presence or absence of overlap in the 95% confidence limits.

3 RESULTS

3.1 Susceptibilities to eight insecticides of *L. lucorum*

Contact toxicity of endosulfan to adult *L. lucorum* was high with the LC_{50} values ranged from 1.06 μg/mL to 6.40 μg/mL. Toxicity data indicated that *L. lucorum* collected in LC was more susceptible to endosulfan than that collectd in LS, DZ, QF and BZ. The LC_{50} value of LC population was 2.27-, 4.19-, 5.48- and 6.04-fold lower than those of LS, DZ, QF and BZ populations, respectively. The populations of *L. lucorum* collected in QF and BZ had a low level tolerance to endosulfan, and other populations were susceptible to this insecticide (Table 1).

Contact toxicity of fipronil to *L. lucorum* was the highest in all insecticides, the LC_{50} values ranged from 0.05 μg/mL to 1.99 μg/mL. Toxicity data indicated that the populations of *L. lucorum* collected in LC and LS were more susceptible to fipronil than other three populations. The LC_{50} value of LC or LS population was 5.40-, 22.80- and 39.80- fold lower than those of DZ, QF and BZ populations, respectively. The populations collected in BZ and QF were more tolerant to fipronil. The DZ population had a low level tolerance to fipronil; the populations collected in LC and LS were susceptible to this insecticide (Table 1).

The contact toxicity of organophosphates malathion and chlorpyrifos to adult *L. lucorum* was at the same level. LC_{50} values for malathion ranged from 3.23 μg/mL and 8.19 μg/mL. And LC_{50} values for chlorpyrifos ranged from 5.95 μg/mL and 10.64 μg/mL. All the populations of *L. lucorum* were susceptible to malathion and chlorpyrifos at LC_{50} values. Toxicity data indicated that green plant bugs collected in LC were more susceptible to malathion and chlorpyrifos than those collected in other four regions. The LC_{50} values of LC population were more or less 1.50-fold lower than those of the other populations (Table 1).

The contact toxicity of methomyl to the green plant bug was very high. The LC_{50} values for *L. lucorum* adults to methomyl ranged from 0.34 μg/mL to 7.52 μg/mL at five locations. Toxicity data indicated that *L. lucorum* adults collected in LC was more susceptible to methomyl than those collected in other four regions. The LC_{50} value of LC population was

Table 1 The susceptible levels of 5 *Lygus lucorum* populations in Shandong Province to 8 insecticides

Insecticide	Population	n[†]	LC_{50} (μg/mL) (95% CL)	Slope ± *SE*	LC_{50} ratio[‡]
Endosulfan	BZ	210	6.40(4.22-12.31)	2.35±0.45	6.04
	QF	210	5.81(5.30-6.37)	2.77±0.17	5.48
	DZ	210	4.44(4.26-4.61)	2.94±0.07	4.19
	LS	210	2.41(2.15-2.74)	2.91±0.23	2.27
	LC	210	1.06(1.03-1.10)	2.81±0.06	1.00
Fipronil	BZ	210	1.99(1.72-2.29)	2.58±0.22	39.80
	QF	210	1.14(1.02-1.26)	2.51±0.15	22.80
	DZ	210	0.27(0.25-0.30)	2.90±0.16	5.40
	LS	210	0.05(0.04-0.06)	2.63±0.19	1.00
	LC	210	0.05(0.05-0.06)	2.79±0.21	1.00
Malathion	LS	210	8.19(7.52-8.91)	2.62±0.14	2.54
	DZ	210	6.12(5.38-6.96)	2.97±0.25	1.89
	QF	210	3.72(3.41-4.06)	2.43±0.13	1.15
	BZ	210	3.57(2.94-4.55)	2.82±0.42	1.11
	LC	210	3.23(3.04-3.43)	3.22±0.13	1.00
Chlorpyrifos	DZ	210	10.64(9.19-12.32)	2.67±0.23	1.79
	BZ	210	10.47(7.14-17.91)	3.38±0.56	1.76
	LS	210	6.87(6.02-7.83)	2.95±0.26	1.15
	QF	210	6.69(6.16-7.26)	2.81±0.15	1.12
	LC	210	5.95(5.36-6.60)	2.93±0.20	1.00
Methomyl	QF	210	7.52(6.97-8.12)	2.42±0.10	22.12
	BZ	210	1.74(1.26-2.82)	2.00±0.46	5.12
	DZ	210	1.67(1.55-1.81)	2.57±0.13	4.91
	LS	210	1.55(1.46-1.64)	3.22±0.13	4.56
	LC	210	0.34(0.31-0.36)	2.57±0.13	1.00
Carbosulfan	QF	210	34.00(29.03-39.82)	2.34±0.21	3.76
	LC	210	17.96(16.95-19.03)	2.38±0.09	1.99
	LS	210	17.39(16.86-17.94)	2.33±0.05	1.92
	DZ	210	16.27(15.92-16.62)	3.22±0.05	1.08
	BZ	210	9.04(6.59-13.29)	2.40±0.45	1.00
Bifenthrin	BZ	210	2.89(2.17-4.44)	2.56±0.50	3.66
	DZ	210	2.54(2.16-2.98)	2.31±0.20	3.22
	QF	210	1.68(1.57-1.80)	2.37±0.10	2.13
	LS	210	1.26(1.14-1.40)	2.93±0.19	1.59
	LC	210	0.79(0.74-0.85)	3.17±0.15	1.00
Imidacloprid	BZ	210	751.22(693.7-813.52)	2.74±0.14	6.17
	LC	210	163.77(152.34-176.06)	2.53±0.12	1.34
	QF	210	155.56(123.75-195.54)	1.68±0.13	1.28
	LS	210	137.93(122.65-155.12)	1.15±0.04	1.13
	DZ	210	121.79(107.52-137.95)	1.47±0.06	1.00

DZ: Dezhou population; LS: Liangshan population; QF: Qufu population; BZ: Binzhou population; LC: Liaocheng population.

[†] Total number of *L. lucorum* adults tested including controls.

[‡] LC_{50} ratio estimated as LC_{50} ratio = The LC_{50} values of each population/The LC_{50} value of the most susceptible population.

22.12-, 5.12-, 4.91- and 4.56-fold lower than those of QF, BZ, DZ and LS populations, respectively. The populations collected in QF were more tolerant to methomyl. The populations of *L. lucorum* collected in LS, DZ and BZ had a low level tolerance to methomyl (Table 1). The LC_{50} values for carbosulfan ranged from 9.04 μg/mL to 34.00 μg/mL for green plant bug adults at all locations. All the populations of *L. lucorum* showed susceptibility to carbosulfan at LC_{50} values. Toxicity data indicated that *L. lucorum* adults collected in BZ was more susceptible to carbosulfan than those collected in other four regions. The LC_{50} value of BZ population was more or less 2.00-fold lower than those of the other populations (Table 1).

The contact toxicity of bifenthrin to the green plant bug was very high. The LC_{50} values for the bifenthrin to different populations ranged from 0.79 μg/mL to 2.89 μg/mL. Toxicity data indicated that *L. lucorum* adults collected in LC was more susceptible to bifenthrin than those collected in other four regions. The LC_{50} value of LC population was 3.66-, 3.22-, 2.13- and 1.59-fold lower than those of BZ, DZ, QF and LS populations, respectively. All the populations of *L. lucorum* showed susceptibility to bifenthrin at LC_{50} values (Table 1).

The LC_{50} values for imidacloprid to five *L. lucorum* populations ranged from 124.79 μg/mL to 751.22 μg/mL (Table 1). The contact toxicity of imidacloprid was lowest in all the insecticides tested for the green plant bug. The BZ population was the least susceptible population to imidacloprid, but the susceptibilities of other four *L. lucorum* populations were similar (Table 1).

3.2 Susceptibilities monitoring to some insecticides in different months

The LC_{50} values of endosulfan to Xiajin (Dezhou, China) population decreased from 5.53 to 2.76 μg/mL during July and October, in 2009. Data of contact toxicity of bifenthrin and methomyl to *L. lucorum* adults were basically unchanged from July to October in 2009, while the LC_{50} values were above at the 2 μg/mL. The LC_{50} values of malathion to *L. lucorum* adults ranged from 6.12 μg/mL to 7.78 μg/mL, and those of chlorpyrifos to *L. lucorum* adults ranged from 8.72 μg/mL to 10.95 μg/mL, Little changes were found in the susceptibilities to these two organophosphates insecticides tested. Although the LC_{50} values of carbosulfan to *L. lucorum* adults continued to increase from the 14.14 μg/mL to the 30.42 μg/mL during July and October, the susceptibility slightly reduced. The contact toxicity of imidacloprid changed little in four months. The LC_{50} values of fipronil to *L. lucorum* adults ranged from 0.13 μg/mL to 0.43 μg/mL, with little changes (Table 2).

4 DISCUSSION

By monitoring the susceptibility of *L. lucorum* collected from 5 regions in Shandong Province, we found that the green plant bugs from different regions were susceptible to malathion, chlorpyrifos, carbosulfan, bifenthrin and imidacloprid at LC_{50} values. The results indicated that the populations collected in BZ and QF was less susceptible to methomyl, endosulfan and fipronil at LC_{50} values. But other populations were susceptible to these three insecticides. Based on field surveys, we found that there was an outbreak of *L. lucorum* in the cotton fields beginning in 2003 in Shandong Province, and in recent years it has risen as a major pest to economic crops. This study is the first susceptibility detection of *L. lucorum* populations from different regions in Shandong Province. The information from this study would be helpful for the management of the green plant bug on cotton in these regions.

In this study, the contact toxicity of fipronil was the highest among the tested 8 insecticides, although the populations collected in QF and BZ were tolerant to fipronil, and DZ population was also less susceptible to fipronil. Similarly, a number of studies had shown that the field application of fipronil to *L. lucorum* was also very effective (Li *et al.*, 2007). However, fipronil is toxic to aquatic crustaceans, fish, shrimp and crab, and slowly metabolized in the environment. Since October 1, 2009, except for being used as the hygienic insecticides and seed coating agents, other applications of fipronil have been banned in China. In our previous study, Zhang *et al.* (2009) found that the contact toxicity of phenylpyrazoles butene-fipronil to green plant bug adults was high with the LC_{50} value of 0.16 μg/mL. These results indicated butene-fipronil may be a good candidate insecticide to control *L. lucorum* in the future.

Endosulfan, a cyclodiene insecticide, has relatively high acute contact toxicity to *L. lucorum* adult, which was occasionally used for management of cotton pests in those five different cotton production regions in these years. Endosulfan shares the same target site, *i. e.* the GABA receptor with fipronil. The low-level tolerance in QF and BZ populations of *L. lucorum* to endosulfan may be a

Table 2 The susceptibilities of *Lygus lucorum* adults to some insecticides from Dezhou from July to October in 2009

Insecticide	Month	n[†]	LC$_{50}$ (μg/mL) (95% CL)	Slope ± *SE*	Relative toxicity index[‡]
Endosulfan	Jul.	210	5.53(3.36 – 13.99)	2.81 ± 0.63	1.00
	Aug.	210	4.44(4.26 – 4.61)	2.94 ± 0.07	0.80
	Sep.	210	3.63(3.32 – 3.98)	2.77 ± 0.17	0.66
	Oct.	210	2.76(2.28 – 3.51)	2.55 ± 0.38	0.50
Malathion	Jul	210	7.78(5.12 – 14.81)	2.88 ± 0.52	1.00
	Aug.	210	6.12(5.38 – 6.96)	2.97 ± 0.25	0.79
	Sep.	210	7.18(6.78 – 7.61)	2.38 ± 0.09	0.92
	Oct.	210	6.69(4.74 – 10.94)	2.50 ± 0.41	0.86
Chlorpyrifos	Jul.	210	9.31(5.87 – 19.15)	2.81 ± 0.52	1.00
	Aug.	210	10.64(9.19 – 12.32)	2.67 ± 0.23	1.14
	Sep.	210	10.95(10.65 – 11.26)	2.55 ± 0.04	1.18
	Oct.	210	8.72(6.15 – 14.17)	2.67 ± 0.42	0.94
Bifenthrin	Jul.	210	1.53(1.21 – 2.06)	2.73 ± 0.52	1.00
	Aug.	210	2.54(2.16 – 2.98)	2.31 ± 0.20	1.66
	Sep.	210	0.82(0.76 – 0.88)	2.53 ± 0.12	0.54
	Oct.	210	2.01(1.42 – 3.54)	2.39 ± 0.56	1.31
Methomyl	Jul.	210	2.22(1.85 – 2.90)	9.66 ± 1.63	1.00
	Aug.	210	1.67(1.55 – 1.81)	2.57 ± 0.13	0.75
	Sep.	210	2.11(1.91 – 2.33)	2.58 ± 0.16	0.95
	Oct.	210	1.63(1.26 – 2.45)	2.31 ± 0.49	0.73
Carbosulfan	Jul.	210	14.14(12.34 – 16.21)	2.72 ± 0.25	1.00
	Aug.	210	16.27(15.92 – 16.62)	3.22 ± 0.05	1.15
	Sep.	210	16.89(15.32 – 18.61)	2.58 ± 0.16	1.19
	Oct.	210	30.42(14.32 – 110.30)	3.05 ± 0.61	2.15
Imidacloprid	Jul.	210	157.83(56.65 – 854.49)	2.25 ± 0.42	1.00
	Aug.	210	121.79(107.52 – 137.95)	1.47 ± 0.05	0.77
	Sep.	210	182.49(150.92 – 220.67)	1.07 ± 0.06	1.16
	Oct.	210	285.35(123.17 – 924.77)	2.11 ± 0.37	1.81
Fipronil	Jul.	210	0.13(0.12 – 0.15)	2.81 ± 0.15	1.00
	Aug.	210	0.27(0.25 – 0.30)	2.90 ± 0.16	2.02
	Sep.	210	0.43(0.42 – 0.45)	2.33 ± 0.05	3.21
	Oct.	210	0.34(0.27 – 0.42)	2.55 ± 0.38	2.62

[†] Total number of *L. lucorum* adults tested including controls.

[‡] Relative toxicity index = The LC$_{50}$ values of DZ population from July to October/The LC$_{50}$ value of DZ population in July.

consequence of cross-resistance with fipronil.

Organophosphates, such as malathion and chlorpyrifos are recommended for controlling of tarnished plant bugs, and malathion is the most widely used organophosphate for control of *L. lineolaris* (Zhu *et al.*, 2004). Based on our study, malathion and chlorpyrifos had higher acute contact toxicity to green plant bug adults and should be recommended to control this pest. Carbamates, methomyl showed high acute contact toxicity to green plant bugs, while carbosulfan had slightly lower activity. Although carbosulfan has been extensively used in Shandong and other cotton growing regions in China for controlling other cotton pests since the mid 1990s (Wang *et al.*, 2007), *L. lucorum* is still susceptible to this pesticide. Therefore, methomyl and carbosulfan could be a good candidate as alternative to fipronil for managing green plant bugs on cotton and other crops. As we expected, all populations of *L. lucorum* were still susceptible to bifenthrin. A neonicotinoid insecticide, imidacloprid has been used in the cotton regions for more than 10 years, and exhibits excellent efficacy in controlling piercing-sucking insects on cotton, such as whitefly and aphids. However, we found that *L. lucorum* adults collected from all five regions were still susceptible to imidacloprid, but the data of contact toxicity was very low. According to our results, malathion, chlorpyrifos methomyl, endosulfan and bifenthrin should be recommended for rotation to delay the resistance of agents to *L. lucorum*.

In this study, we chose five cotton-producing regions from four prefecture-level cities in Shandong Province, and we can see from the map (Fig. 1) that the regions are far away from each other. Though *L. lucorum* adults have sufficient capability for long-distance flight (Lu, 2008), the *L. lucorum* could oviposit in plants and soil, and successfully live through the winter in each monitoring region in Shandong Province which has suitable ecological environment for green plant bugs to survive. Among different populations, there maybe have little chance to cross-migrate, so a variety of inter-group interactions do not exist. The results of this study showed that the data of contact toxicity of endosulfan, bifenthrin, malathion, chlorpyrifos, methomyl and fipronil to adult *L. lucorum* were high, and all populations of *L. lucorum* were mostly susceptible to these insecticides. Carbosulfan had an intermediate-level toxicity to the green plant bug, and susceptibilities among different populations of various regions were at the same level. Contact toxicity of imidacloprid to *L. lucorum* was very low, but the susceptibilities of different *L. lucorum* populations did not differ significantly to this insecticide. So we could conclude that green plant bugs of Shandong populations were all at the susceptible levels. The insecticides had been used in the same level in these five regions. It may be one reason why the *L. lucorum* from Shandong was at the same susceptible stage.

We collected *L. lucorum* adults from cotton in July and the weed *H. scandens* near the cotton field during August and October in Xiajin (Dezhou). From July 1 to August 26, malathion, chlorpyrifos, carbosulfan, imidacloprid were used to control green plant bugs and aphids on cotton once a week. But the susceptibilities to 8 insecticides of *L. lucorum* adults were hardly changed from July to October in 2009. These were probably caused by fewer contacts to insecticides because of strong flight force.

In conclusion, *L. lucorum* populations from tested fields in Shandong Province were still at a susceptible level to common insecticides. As a long-term research, further susceptibility monitoring should be performed in these five fields.

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山东省五个棉花产区绿盲蝽对药剂的敏感性检测

郭天娥, 张正群, 周　超, 刘　峰, 慕　卫*

(山东农业大学植物保护学院, 山东省农药毒理与应用技术重点实验室, 山东泰安 271018)

摘要: 利用闪烁管药膜法测定了 2009 年山东省德州、滨州、梁山、曲阜和聊城 5 个棉花产区绿盲蝽 *Lygus lucorum* Meyer-Dür 对硫丹、马拉硫磷、毒死蜱、灭多威、丁硫克百威、吡虫啉、联苯菊酯和氟虫腈 8 种杀虫剂的敏感性, 筛选出适合各地区的高效防治药剂。结果表明: 5 个地区绿盲蝽种群对马拉硫磷、毒死蜱、丁硫克百威、联苯菊酯和吡虫啉处于敏感性阶段。不同种群之间对灭多威、硫丹和氟虫腈的敏感性差异较大, 其中聊城种群为最敏感种群, 滨州种群对灭多威、硫丹和氟虫腈的 LC_{50}值分别为聊城种群的 5.12, 6.04 和 39.80 倍; 曲阜种群对灭多威、硫丹和氟虫腈的 LC_{50}值分别为聊城种群的 22.12, 5.48 和 22.80 倍。两种群对此 3 种药剂的敏感性下降, 而其余种群仍处于较敏感阶段。8 种药剂对绿盲蝽成虫的毒力按大小依次排序为: 氟虫腈 > 灭多威、联苯菊酯、硫丹 > 马拉硫磷、毒死蜱 > 丁硫克百威 > 吡虫啉。2009 年 7 – 10 月间德州夏津绿盲蝽种群对 8 种杀虫剂的敏感性变化极微。

关键词: 绿盲蝽; 棉花; 田间种群; 抗性; 杀虫剂敏感性; 杀虫剂; 毒力

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